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METHOD, APPARATUS AND SYSTEM FOR AUTOMATED SPINE LABELING

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a 371 National Stage Application of PCT/EP2013/065457, filed Jul. 23, 2013. This application claims the benefit of U.S. Provisional Application No. 61/678,108, filed Aug. 1, 2012, which is incorporated by reference herein in its entirety. In addition, this application claims the benefit of European Application No. 12177656.1, filed Jul. 24, 2012, which is also incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method and a corresponding apparatus and system for automated labeling of a spine in an image, in particular a computed tomography (CT) image, of a human or animal body.

2. Description of the Related Art

The acquisition of CT images with and without contrast agent of abdomen, thorax and/or neck is a routine procedure for the diagnosis of a multitude of diseases or injuries. The spinal column represents a natural reference structure of the upper part of the body for describing the locations of organs and pathologies. To be used as a reference system in daily clinical routine, the vertebrae and/or intervertebral disks in the image have to be labeled. A manual labeling can be time consuming, especially if only arbitrary parts of the spine are visible in the data. Therefore, automatic approaches are of interest which deliver labeling results after image acquisition without any user interaction.

For the labeling task, a sparse localization of spine components, e.g. vertebrae and/or disks, is sufficient. Within this context, the term “sparse” refers to the requirement according to which correct anatomical labels should be visible in all views showing a certain vertebra or intervertebral disk, and optionally also in a 3D rendering. This does not necessarily require a full segmentation of all spinal structures. The localization of centers of disks and vertebrae and a coarse approximation of their extent delivers adequate results.

Although this task seems to be trivial, the realization of a fully automatic labeling system for 3D CT data supporting radiologists is challenging: The labeling should be available within a reasonable time in order to guarantee a fast diagnosis after image acquisition. Nonetheless, the labeling algorithm has to reliably handle varying resolution and image quality, showing spinal columns with variations in size, shape, bone densities and varying number of vertebrae. Presence of contrast agent or pathologies like scoliosis, collapsed disks, broken vertebrae, degenerative changes or fused vertebrae based on surgical procedures make high demands on the flexibility of the chosen methods.

SUMMARY OF THE INVENTION

Preferred embodiments of the invention provide a method, apparatus and system for automated labeling of a spine in an image of a human or animal body with high reliability and high image throughput.

The advantages and benefits of the preferred embodiments are achieved by the method, apparatus and system as defined below.

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The method according to a preferred embodiment of the invention comprises the following steps: a) matching a model of a spine segment with segments of the spine in the image by starting matching said model of a spine segment with an initial segment of the spine in the image, wherein said initial segment of the spine in the image being located at an initial position along the spine in the image, and by continuing matching said model of a spine segment with one or more further segments of the spine in the image, wherein said further segments of the spine in the image being located at further positions along the spine in the image, wherein said model of a spine segment relates to anatomical properties of one or more parts of a spine, and b) labeling one or more parts of the spine in the image in response to step a).

The apparatus according to preferred embodiment of the invention comprises an image processing unit for executing and/or controlling the following steps: a) matching a model of a spine segment with segments of the spine in the image by starting matching said model of a spine segment with an initial segment of the spine in the image, wherein said initial segment of the spine in the image being located at an initial position along the spine in the image, and by continuing matching said model of a spine segment with one or more further segments of the spine in the image, wherein said further segments of the spine in the image being located at further positions along the spine in the image, wherein said model of a spine segment relates to anatomical properties of one or more parts of a spine, and b) labeling one or more parts of the spine in the image in response to step a).

The system according to preferred embodiment of the invention comprises an image acquisition unit, in particular a computed tomography (CT) unit, for acquiring at least one image of at least a part of a human or animal body and an apparatus for automated labeling of a spine in an image.

The preferred embodiments of the invention include a fully automatic algorithm for labeling arbitrary parts of the vertebral column shown in CT data. The algorithm finds an initial position with its anatomical label by detection of reference regions (e.g. sacrum) and subsequently labels all remaining visible disks and vertebrae automatically. Preferably, a high-performance method for sparse structure localization by Markov Random Fields (MRF) is applied, wherein sparse 3-disk MRF models are built and, starting from the initial position, propagated to all parts of the spine. Preferably, a boosted decision tree based feature detection method inside regions of interest is used for optimization of the MRF model matching. Moreover, prior knowledge on spine anatomy and appearance is considered.

Due to the preferred embodiments of the invention, high precision results—even for CT scans of only few vertebrae—are obtained in less time so that both high reliability and high throughput of images to be labeled are achieved. E.g., for volume images constructed from 512×512 axial slices an average labeling precision of 99.0% in about 2 minutes is achieved.

In the context of the invention, the term “part of a spine” preferably relates to a vertebra or intervertebral disk of a spine. The terms “spine segment” and “segment of a spine” preferably relate to a portion of a spine comprising one or more parts of the spine, in particular one or more vertebrae and/or intervertebral disks. Accordingly, an “initial segment of the spine” or a “further segment of the spine” comprises one or more parts of the spine located at an initial or a further position, respectively, on or along the spine.

The term “matching” or “to match” in the sense of the invention relates to a comparison of said model of a spine segment with segments of the spine in the image and/or an